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学位授与の題目	The late-intrusive rocks in the Oman ophiolite:their implications for the origin of ophiolite and for the formation of intra-oceanic arc.（オマーン・オフィオライトの後期貫入岩類：そのオフィオライトの起源および海洋性島弧の形成における意義）
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学位論文要旨

The Oman ophiolite is one of the largest and best preserved ophiolites in the world. This ophiolite is thus regarded as the best place to investigate in detail the oceanic lithosphere on land. On the other hand, non-oceanic igneous rocks have also been reported from the Oman ophiolite. One of these rocks is the late-intrusive plutonic rock. The late-intrusive plutonic rock and picrite, and the reaction between the late-intrusive plutonic rock and layered gabbro was examined in the northern Oman ophiolite. Petropraphy, whole rock and mineral chemistry and whole rock geochemical features suggest that the late magmatic igneous rocks belong to two rock series and that they have remarkable subduction-zone affinity. Subduction-zone setting was achieved by the intra-oceanic thrusting near ridge. Two distinct subduction zone magmatism had occurred during the obduction of the Oman ophiolite. The reaction between the late-intrusive plutonic rock and layered gabbro produced trondhjemite, gabbro and anorthosite melts. They were formed by anatexis of layered gabbro by the heat of late intrusive plutonic rock. This reaction is interpreted as the modification process of oceanic crust during changing of tectonic setting from ocean to arc.

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The ol-cumulate intrusive rocks are ol-cumulate with interstitial clinopyroxene, plagioclase, hornblende and orthopyroxene. Lithofacies of these intrusions vary from dunite to olivine gabbro through troctolite Hornblende is included in almost all intrusive rocks. The order of crystallization is sp-ol-(cpx, pl, hbl)-opx. The high-level intrusive complex comprises ultramafic rock, gabbro and plagiogranite. The ultramafic rock are ol-cpx cumulate includes wehrlite and plagioclase lherzolite intercalate with gabbro and norite layers. Hornblende is also included. The order of crystallization is sp-ol-cpx-(pl, hbl, opx). The Cr# of chromian spinel in ol-cumulate intrusive rocks and the high-level intrusive rocks is distinctively high (over 0.6). Fo content of olivine, Fe^{3+}# and TiO_2 content of spinel, and Cr_2O_3 and TiO_2 content of clinopyroxene of both intrusions lie on the same compositional trend. Petrographycal similarity suggest that these two intrusive rocks belong to the same rock series and that the high-level intrusion was formed from differentiated magma. Mineral compositions of both intrusive rocks are on the same trend

Picrites are divided into three types in petrography. Type 1 is characterized by euhedral phenocrysts of olivine, chromian spinel and cliopyroxene, and abundant vesicles. The order of crystallization is sp-ol-cpx. Type 2 is characterized by slow cooling texture and absence of vesicles. The order of crystallization is sp-ol-(cpx, amp, pl?)-(opx, pl?). Type 3 is characterized by opx phenocrist and abundant plagioclse. The order of crystallization is sp-ol-(cpx, opx)-pl. Type 1 and Type 2 picrite are almost the same in the whole rock chemical composition except TiO_2 content, which is slightly higher in TiO_2. Type 3 picrite is clearly lower in TiO_2 content than the other two types. Chromian spinels and clinopyroxenes in Type 2 picrite are higher in TiO_2 content than the other two picrites. Trace element distribution patterns of Type 1 and 2 picrite shows almost flat REE pattern and strong negative Nb, Ta and Th anomaly. Type 3 picrite shows U-shaped REE pattern and Ta enrichment with Nb negative anomaly. The Cr# of chromian spinels in all picrite is high (up to 0.8). Petrographical and chemical features suggest that Type 1 and 2 picrites were formed from the same magma. Petrographycal and slight chemical differences are due to the slower cooling of the Type 2 picrite.

The similarity of petrography, mineral compositions and geochemical features are suggestive of the genetic relation between the ol-cumulate intrusions, Type 1 and 2 picrites. The ol-cumulate intrusions are the plutonic equivalents of Type 1 and 2 picrites. The MgO content of primal magma of Type 1 picrite is estimated to 14.3 to 17.6 wt%. Genetic relation between boninite and Type 3 is inferred from the early appearance of orthopyroxene, low-TiO_2 content and U-shaped REE pattern. Type 3 picrite represent the primitive equivalent of boninite. The plutonic equivalent of Type 3 picrite may be the opx-series intrusion. Petrographical, chemical and geochemical features indicating subduction-zone setting are detected from both late-intrusive plutonic rock and picrites. They are primal hydrous minerals, high-Cr# chromian spinels and negative anomaly of Nb and Ta.

Subduction-zone with high thermal structure had been achieved by the intra-oceanic thrusting near the ridge. The source mantle of picrite was already depleted mantle peridotite once melted on the mid-ocean ridge setting. The source mantle for Type 3 picrite was more depleted than that for Type 1 and 2.

At the contact between the late-intrusive plutonic rocks and layered gabbro, clinopyroxenite, melagabbro and leucoclatic to mesoclatic dikes are observed. These dikes are trondhjemite, gabbro, or anorthosite. They are derived from melagabbro and clinopyroxenite and intrude into the surrounding late-intrusive rock. Clinopyroxenes are lower in TiO_2, Al_2O_3 at given Cr_2O_3 content and higher in Mg/(Mg/Fe) ratio in melagabbro and clinopyroxenite than in layered gabbro. Anorthite content of plagioclase and forsterite and NiO contents of olivine are higher in melagabbro than in layered gabbro. Anorthite content of plagioclase in dikes increases from trondhjemite to gabbro, and is generally lower than that in layered gabbro. Anorthosite, layered gabbro, and clinopyroxenite make an almost linear trend in the compositional space. These features suggest that the dikes are partial melt from layered gabbro due to heating by the late-intrusive rock, and that clinopyroxenite and melagabbro are its residue.

This reaction has bearing on the generation of felsic magmas in oceanic crust and is an analogue of modification of oceanic crust during the transition of tectonic setting to island arc system. At the initiation of oceanic arc, oceanic crust is partially melted by subduction-related magmas to produce tonalite and trondhjemite melts. This reaction corresponds to the transition from basaltic oceanic crust to andesitic oceanic arc crust.

Hydrous anorthositie has never been reported from oceanic crust, and has uniquely produced in the Oman Ophiolite because 1) the source rock was silica-undersaturated primitive gabbro, 2) the heat source had high temperature (around 1250℃), 3) the pressure was low (< 0.2 GPa), and 4) the melting occurred at hydrous condition. Such conditions are rarely available on the present Earth but were rather common in Precambrian, when hot oceanic plate subducted more actively.

学位論文審査結果の要旨

上杉次郎君提出の博士論文について、平成16年1月28日に公開発表会を行い、引き続いて審査委員会を開催してその内容と評価を議論した。論文の内容の概要及び審査結果は以下の通りである。

上杉君は、古来有名なオマーン・オフィオライトの後期貫入岩類を詳細に検討した。オマーン・オフィオライトは基本的には海洋リソスフェアの断片であるが、最近の研究により、島孤的な環境を示唆する噴出岩が発見されている。上杉君の得た知見は以下の通りである。1）後期貫入岩類およびその噴出相であるピクライトはMgに富むかんらん石およびCrに富むスピネルにより特徴付けられ、島孤的環境を示唆する。2）後期貫入岩類の貫入により、海洋地殻が融解し、フェルシック・メルトを生成し、溶け残りの単斜輝石岩を形成している。3）後期貫入岩の生成により、モホ（地殻とマントルの境界）に多様性を生じさせている。4）これらの、諸過程は海洋地殻の島孤地殻への変遷に相当し、オフィオライトからは、海嶺過程および海洋リソスフェアの構造のみならず、島孤（特に海洋性島孤）の生成過程の情報を引き出すことが可能である。以上の成果は、オフィオライトの本質を明確にしたのみならず、新たな重要な側面を提示したものとして高く評価される。また、今後の深海掘削計画の立案において、彼の研究成果は十分に考慮されるべき重要性を有する。従って、本審査委員会は、本提出論文は上杉君に博士（理学）の学位を与えるのに十分な内容を有していると判断する。